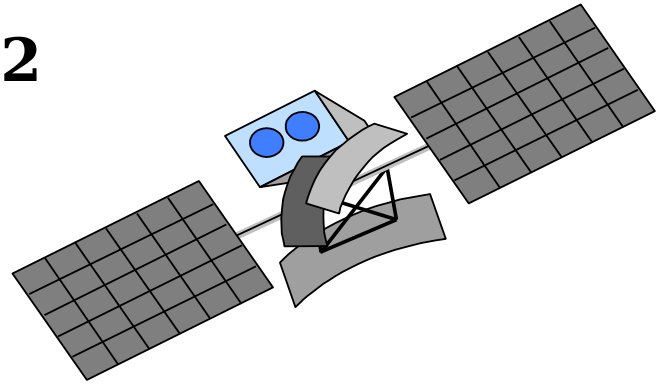
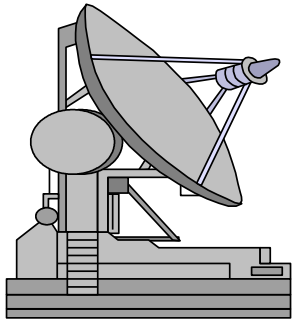
Wireless Telemetry for Industrial Applications

DARPA PI Meeting

Santa Fe - January 2002





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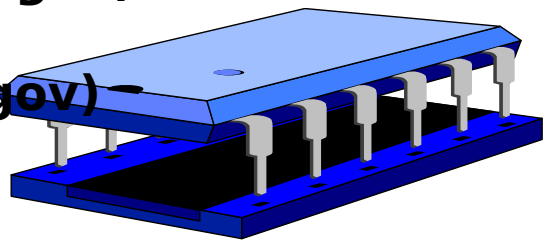


Http://orcmt.oakridge.org/wireless

OAK RIDGE NATIONAL LABORATORY
U. S. DEPARTMENT OF ENERGY

UT-BATTELLE

ORNL's Wireless Program Focuses on Industrial Applications For Government Benefit

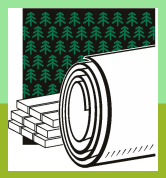
- Dept. of Energy - Office of Industrial Technology, Sensors and Controls
- CRADA partners - oil, Graviton, others
- DOD - Navy and Navy contractor, others
- Path Forward - smaller, faster, cheaper

Industries of the Future Strategy

Technology for Today

Support RD&D for 9 energy-intensive industries

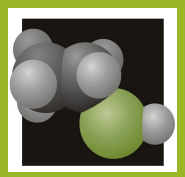
- **Industry-specific technologies**
- **Enabling (cross-cutting) technologies**



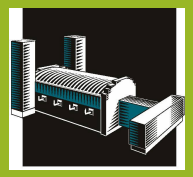
Forest Products

Agriculture

Aluminum



Chemicals



Glass

Metalcasting

Mining

Petroleum Refining

Steel

Technology for the Future

Deliver Available Tools

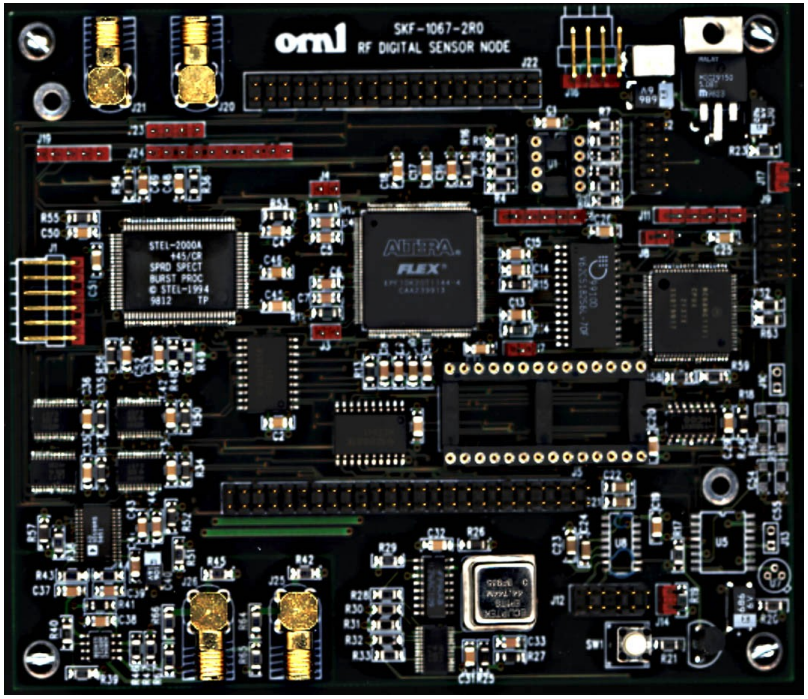
Sensors & Control Program Objective

- **Provide high-priority crosscutting technology solutions identified in IOF roadmaps, specifically in the areas of**
  - **Advanced sensor technologies**
    - » **Chemical/physical measurements in demanding applications (harsh environments, high-speed, industrial robustness, miniaturization)**
  - **Improved information processing**
    - » **Signal processing, imaging and displays, neural networks, modeling and simulation**
  - **Intelligent control systems**
    - » **Smart control, sensor fusion, automation**

We Accomplished What We Set Out To Do

- **Year 1 - Functional Description and Requirements - some surprises, several external requests**
- **Year 2 - Architecture Specification, components - more external requests**
- **Year 3 - Integrated systems and Demo - external requests and potential partners**

Our Third Year Demo Showed Feasibility



- **Standards - IEEE 1451, Ethernet, 4-20ma**
- **Communication - Direct Sequence, Spread Spectrum, CDMA RF**
- **Robust - 140 feet in Bowater paper mill**

Challenges in Wireless Technology Identified by National Research Council

- **Eliminating Interference - reliable communications**
- **Developing Intelligent Wireless Sensors - reduced deployment cost**
- **Developing Robust Architectures - for harsh environments**
- **Developing Remote Power - long lasting and reliable**
- **Developing Standardized Protocols - plug-and-play (without the plug)**

Key Requirements Identified

- **Operate Unattended - Reduced cost of deployment and maintenance**
  - **self-configuring,**
  - **self starting,**
  - **self healing**
- **Support Legacy Systems - Sensors and networks, open standards (1451)**
- **Operate in Industrial Environment - temperature, dust, vibration**

Demonstration in Bowater Plant Proved Performance

- **Robust - up to 140 feet in harsh environment**
- **Standards - 4-20ma standard pressure and temperature sensors, IEEE 1451 data structures, ethernet**
- **Throughput - updates suitable for real-time displays**
- **Low Power - 1/10000 power density of narrow band systems**

- **Standards - IEEE 1451, Ethernet, 4-20ma**
- **Communication - Direct Sequence, Spread Spectrum, CDMA RF**
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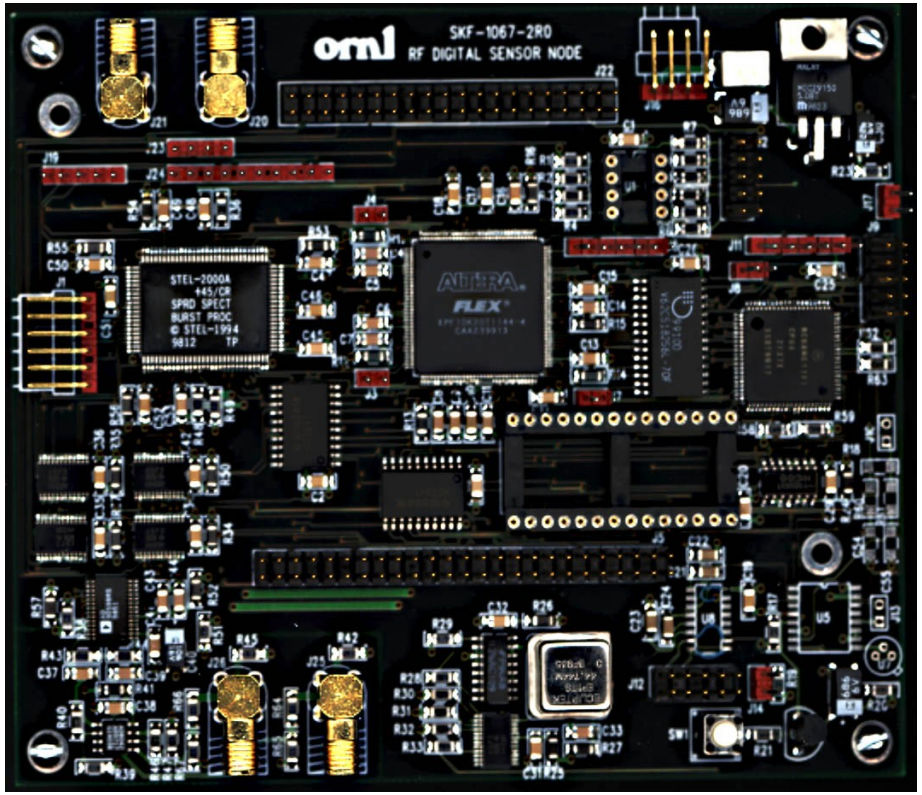
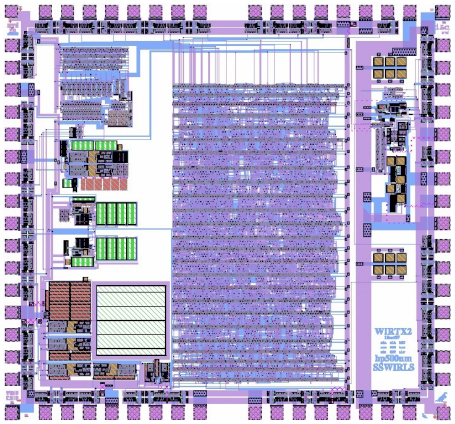
Our Path is Clear

Ground breaking wor

- **Wireless protocols**
- **Mixed Signal ASICS**
- **Low Power Designs**

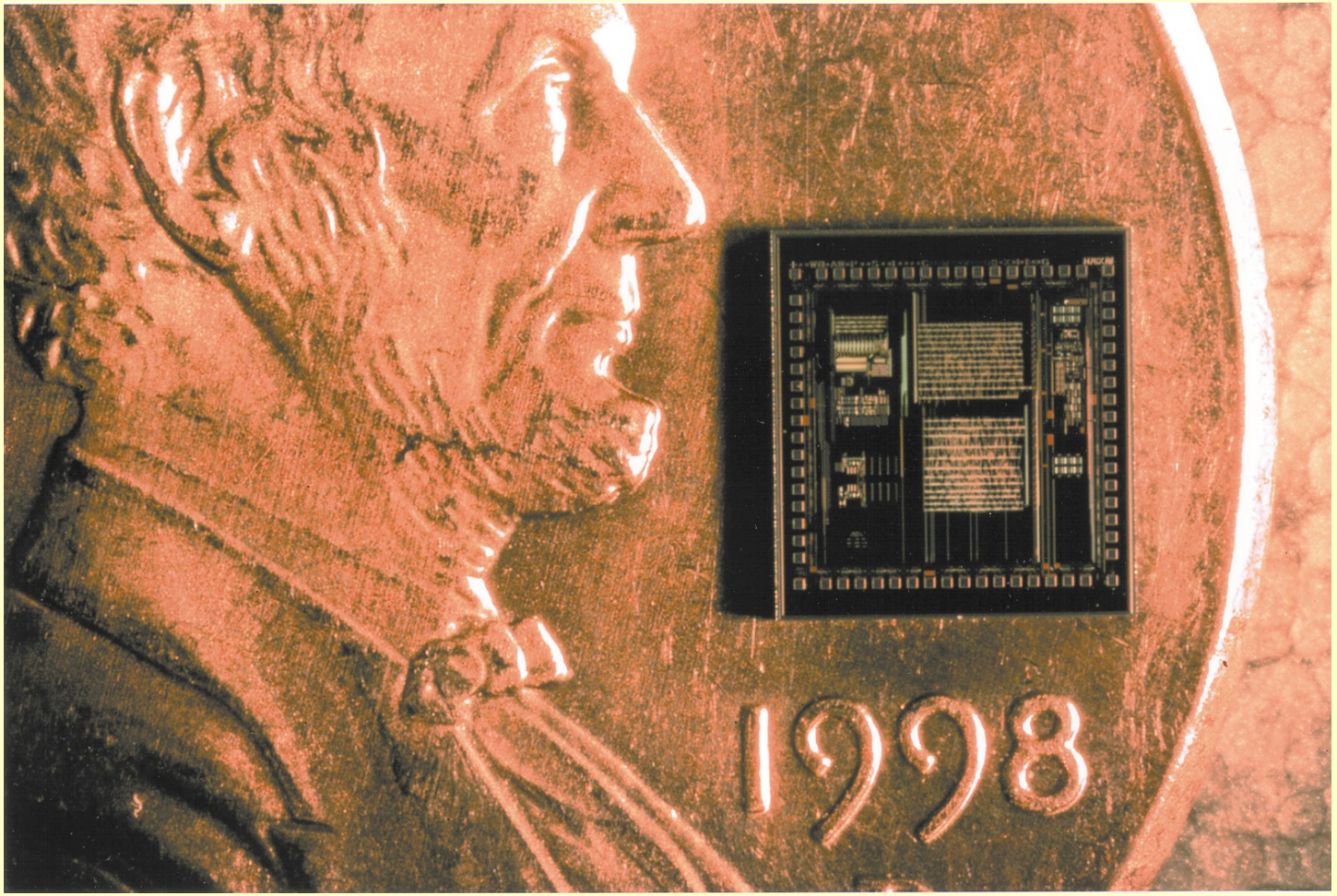


10 cm (4 inches)



3.3 mm (1/8 inch)

MULTI-CHANNEL INTEGRATED SPREAD-SPECTRUM TELESENSOR



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SiGe Work Begun on This Project

- AMS SiGe process has f_T up to 30 GHz, adequate for 5.8 GHz systems
- Two SiGe chips have been designed and submitted for fabrication
  - Individual devices for characterization and model verification
  - Several RF functional blocks needed for a 5.8 GHz bi-directional system

Critical Next Steps Awaiting Funding and Partnerships

- **Self-Powered - harvesting, helium ion-based batteries**
- **Smaller Footprint, Improved Noise Immunity - SiGe ASICS**
- **Reliability - error detection/correction**
- **Embedded Intelligence - Sensor Agents**

Wireless Program at ORNL Provides Significant Leverage

- LDRDs - wireless microsensors, embedded wireless biosensor -
- Commercial Supplier - wireless MEMS –
- Oil Industry - robust architecture -
- Navy - Power management for wireless sensors NASA - launch vehicle status -

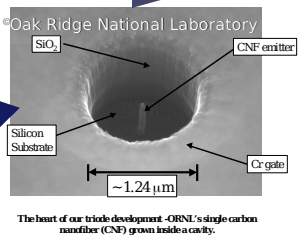
Part of Large, Leveraged R&D Program

IR Free Space Technology

'01 '02 '03 '04

THz Nanotechnology

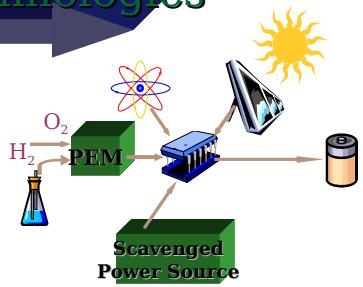
'00 '01 '02 '03



The heart of our triode development -ORNL's single carbon nanofiber (CNF) grown inside a cavity.

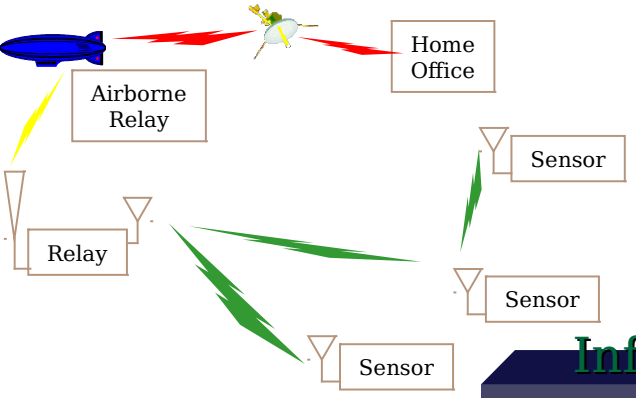
Miniature Power Source Technologies

'01 '02 '03 '04



Mobile Ad-Hoc/Robust Protocols

'99 '00 '01 '02



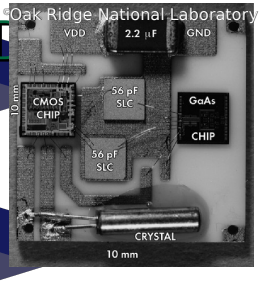
Information/Knowledge Enhancement

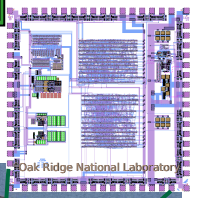
'99 '00 '01 '02

IEEE 1451 Sensor Bus Stds./Networking

'98 '99 '00 '01

Custom ASIC, Analog and Digital Circuit D





Custom RF System Design

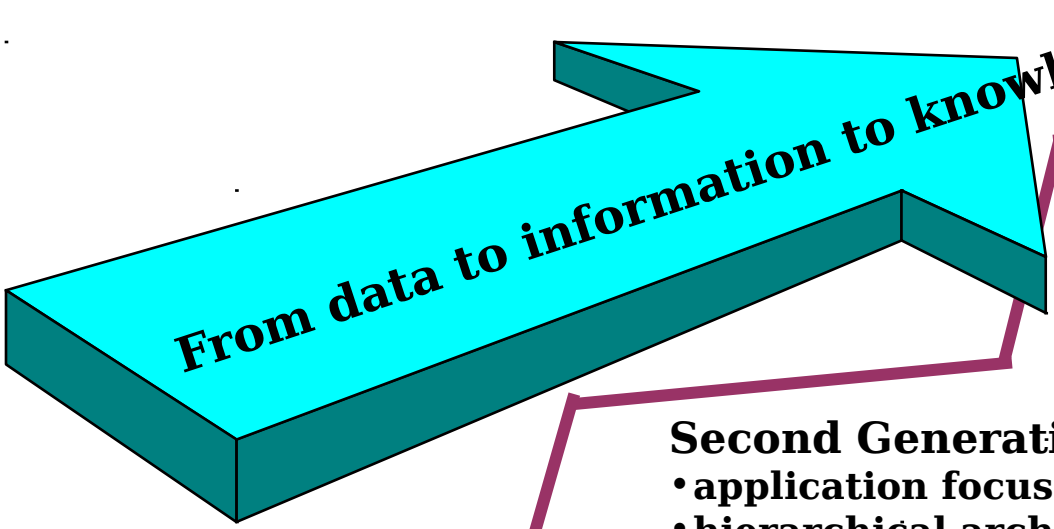
'98 '99 '00 '01

Our Project Highlighted in April 2000 Issue of Sensors Magazine

Follow-up Article in April 2001 Stressed Wireless Sensor Issues

Special Section in August 2001 Issue Stressed Sensor Agents

What Is The Next Generation Sensor System?

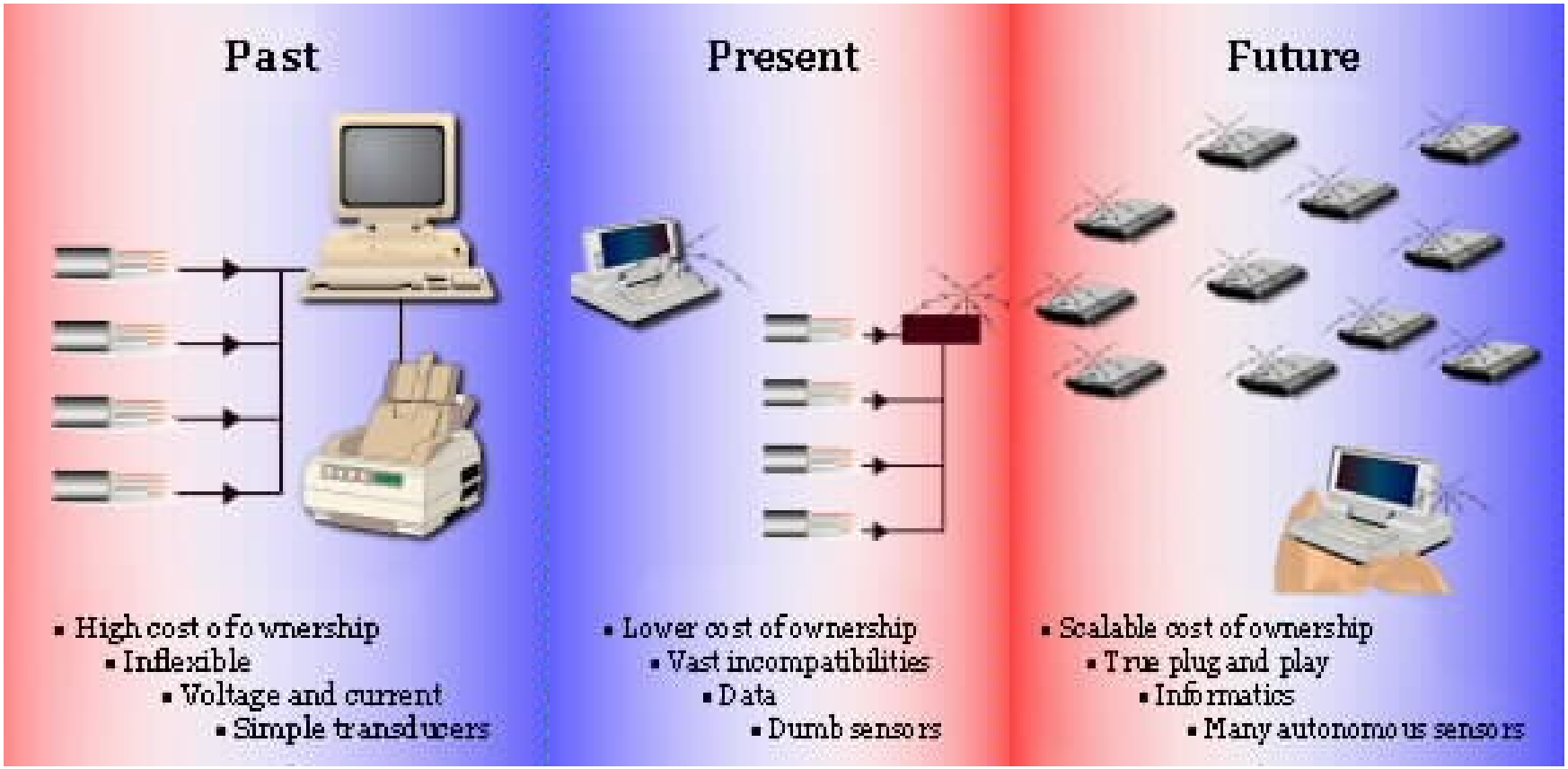


Third Generation - Sensor
- goal focus
- dynamic architecture
- network intelligence

Second Generation - Smart Sensors
- application focus
- hierarchical architecture
- local intelligence

First Generation - Dumb Sensors
- data focus
- flat architecture
- no intelligence

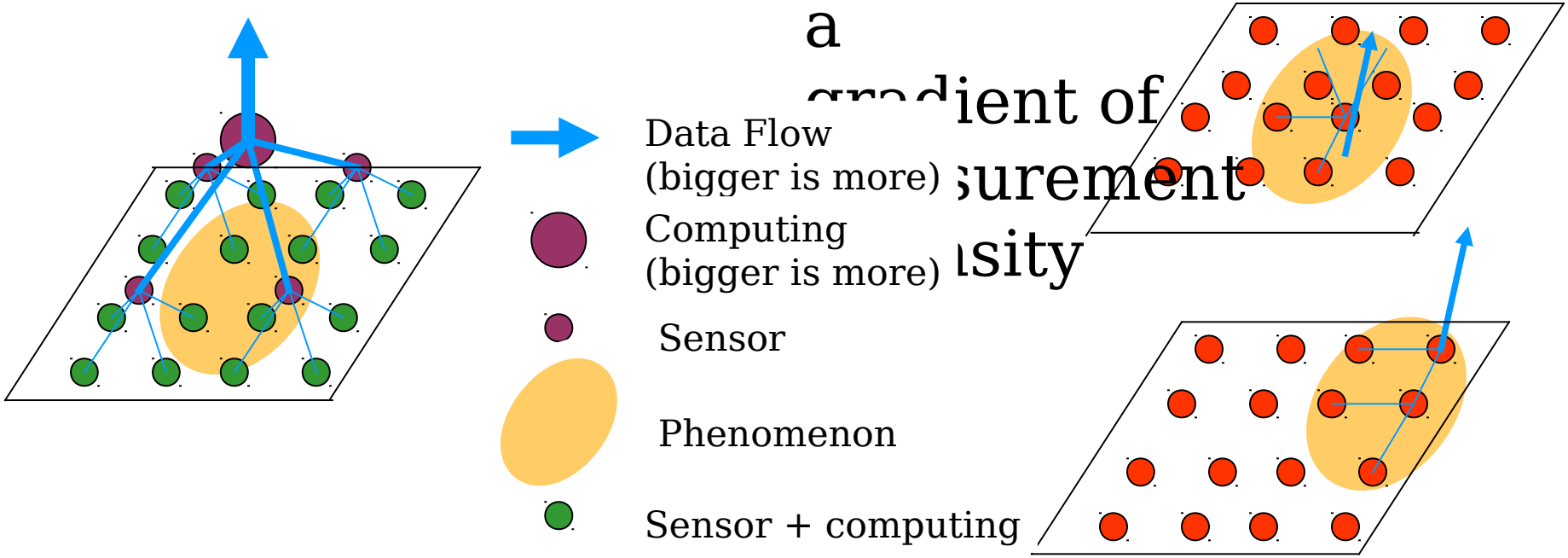
The Future:
The Sensor IS the Network



Next Generation Measurement System Architecture

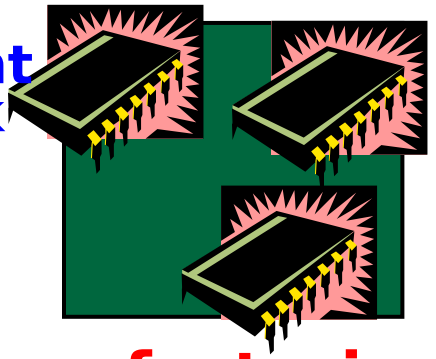
Present-day systems have fixed hierarchy

Next generation network will self-organize in response to a gradient of measurement density



Everybody Wins

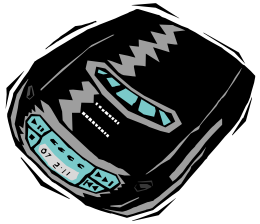
Wireless Intelligent Network

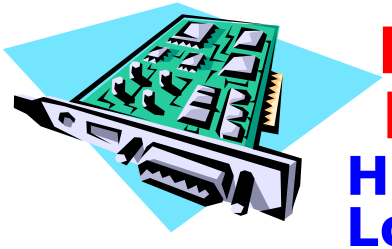


Consumer Market
High Quality
High Volume
Low Cost
Low Integrity

Government
Labs
Academia
Industry

Manufacturing/ Industrial Markets
High Quality
Low Cost
High Volume
High Integrity





National Defense
High Cost
Low Volume
High Quality
High Integrity

Wireless Warrior

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The Government Can No Longer Afford to Be the Only Customer

- State of the Art - Commercial vs Government use
- Emerging Trends - Short term, Medium Term
- Enablers and Disablers - Where help is needed to meet government needs